FACTSHEET

SOILS

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SOIL SAMPLING AND ANALYSIS FOR MANAGING CROP NUTRIENTS

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Soil testing plays an important role in crop production and nutrient management. On farms that use commercial fertilizer as the main nutrient source, it is the best way to plan for profitable fertilizer applications. On livestock farms, knowing how much nutrient is present in the soil to start with is critical. Only then can a nutrient management plan be developed to properly manage both the nutrients that have been generated on-farm and any nutrients that are being imported to the property as biosolids or commercial fertilizer.

Soil testing is really a three-step process: the collection of a representative sample from each field or section, proper analysis of that sample to determine the levels of available nutrients, and use of the results to determine optimum fertilizer rates. Keeping records is an integral part of the soil-testing process; they will help determine if soil test levels are increasing, decreasing or being maintained over time.

SOIL SAMPLING

The sample that is sent to the lab for analysis normally weighs about 400 gm (1 lb), but this sample must accurately represent up to 20,000 t of soil — the amount of soil in 10 ha (25 ac). Clearly, care in the sampling process is necessary.

Sampling Area

Choice of the area to be included in the sample can have a large impact on the accuracy of the soil test. Where fields are small, it is relatively simple to collect a sample for each field, but larger fields must be divided into smaller sampling areas. As much as possible, ensure that each sampling area is uniform and separate from areas that are obviously different.

Variation in soil fertility can occur because of differences in the native fertility of the parent material, the texture of the soil, the amount of nutrient removal by crop growth or the position in the landscape. By far the largest variation, however, comes from past applications of nutrients, either as fertilizer or manure. When the variation is small, include several cores in each sample; when the variation is large, sample areas separately. Where past field boundaries are known, use them to divide large fields into smaller units. Base further subdivision, or divisions where past field boundaries are not know, on soil type or topography. The maximum area included in a single sample should be 10 ha (25 ac).

There is no minimum size for the area that can be represented by a single sample, so precision sampling, site specific sampling or grid sampling are permitted but not required for nutrient management.

Any areas that have obviously different nutrient levels from the balance of the field should not be included in the composite sample for the field. This could include dead furrows, eroded areas, laneways or areas where manure or lime has been piled. If these areas are large enough to be managed separately, sample and analyze them separately.

Sample Depth

The normal sampling depth for nutrients is about 15 cm (6 in.) because most plant roots grow to that depth, and tillage mixes most nutrients into the soil to about 15 cm deep. Subsoil is normally much lower in nutrient content, so sampling too deep will produce a sample that is not representative of the field.

However, when sampling for soil nitrates, a sample down to a depth of 30 cm (1 ft) will provide a more accurate indication of the amount of nitrate available to the crop, since nitrate will move more easily with soil water than other nutrients will.

Sample depth is not changed in a no-till system, even though the nutrients are no longer being mechanically mixed into the soil, with the possible exception of pH samples. It may be appropriate to collect a shallow

sample (5 cm or 2 in.) to check for acidification in the surface layer if nitrogen is being surface applied. Do not use these samples for nutrient analysis, since they will overestimate the nutrient availability from the soil.

Sample Collection

A representative sample from a field must include enough cores, collected randomly from across the entire area. Too few cores increase the risk that a non-representative core could skew the result for the whole field. Non-random sampling increases the risk that a bias could be introduced into the sample. The most efficient way to achieve random sampling is to follow a zig-zag pattern around the field. Collect a minimum of 20 cores to produce the composite sample and one additional core per acre for fields larger than 20 ac.

Often the most overlooked step in collecting a soil sample is the thorough mixing of soil cores before the sub-sample is collected. Sampled soil cores should be mixed in the bucket until no evidence of soil cores exist. Heavy clay soil cores sometimes need to be dried before they can be sufficiently mixed to allow for a suitable sub-sample. The sub-sample should be no more than 400 gm or about 1 cup of soil.

Store collected samples at room temperature, with the exception of soil nitrate samples, which should be kept cool (below 4°C) and delivered to the lab within one day for immediate analysis. Freeze any samples that will not be analyzed immediately as soon as possible.

Sampling Equipment

While it is possible to collect samples using a shovel or spade, it is much more efficient to use a sampling probe or auger. These should be constructed of stainless steel, particularly if the samples are going to be used for micronutrient testing. Many agricultural retailers will lend sampling probes for soil sample collection.

Collect soil cores in a clean plastic pail. Galvanized pails will contaminate the samples with zinc, which will make the analytical results for micronutrients unusable. Avoid pails that have contained sanitizers or detergents, since phosphates from these materials can be carried over into the samples.

A sturdy stainless steel or aluminum trowel works well for mixing the cores before collecting a sub-sample. A screwdriver is also useful for dislodging any soil cores that might get stuck in the sampling tube.

Sample Frequency

Collect samples frequently enough to detect changes in the soil test for a field, before they become large enough to significantly affect crop yields or fertilizer requirements. For most farms, once every three years is adequate for this purpose, and this often works out to once in the rotation, at the same point in the rotation.

Rapid changes in soil test values can occur where the soil has a low capacity to hold nutrients or when crops that extract large amounts of a particular nutrient are grown. More frequent sampling will be necessary on coarse-textured soils or where crops that remove large quantities of potassium are grown such as alfalfa, corn silage or processing tomatoes.

What Does the Regulation Say About Sampling Frequency?

Ontario Regulation 267/03 states that a sample must be collected and analyzed from each field area prior to the completion of each nutrient management plan, and that the results from this sample must be used in the preparation of the plan. This would normally mean the maximum sampling interval would be 5 years, unless a change in the operation made the preparation of a new plan necessary. The exception is a plan for a new operation, where there are default values provided that are high enough to place maximum restriction on nutrient application.

Sampling Time

There is some variation through the year of soil pH and nutrient content, particularly related to soil moisture, but these differences are not large enough or consistent enough to impact a nutrient management plan. Taking soil samples at the same time of year each year eliminates seasonal variation as a factor in comparing soil test results over time. More importantly, if the samples are taken immediately after harvest, the results will be back in plenty of time for planning the fertilizer program for the next crop.

Sample Analysis

Samples for a nutrient management plan must be analyzed at an OMAFRA-accredited lab, using the OMAFRA-accredited tests. The accreditation process assures quality analysis using Ontario-proven methodology.

Table 1, next page, lists accredited labs in Ontario.

Soil testing for available nutrients involves extracting a portion of the nutrient from the soil and then analyzing the extract. The value measured by this process is not the exact physical quantity that is available to the plant. The complexity of soil chemistry and plant uptake is too great to make this measurement possible. Instead, the value measured is related to the amount of nutrient that a plant root can extract. These values can vary widely with different tests. You cannot use the results from different tests with Ontario recommendation tables. The accredited tests have been chosen to provide accurate results in the range of soil conditions found across the province.

TABLE 1.
Accredited Soil Test Laboratories in Ontario

Laboratory	Address	Telephone/Fax
A & L Canada Laboratories Inc.	2136 Jetstream Rd London, ON N5V 3P5	tel: (519) 457-2575 fax: (519) 457-2664 e-mail: aginfo@alcanada.com
Accutest Laboratories	146 Colonnade Rd Unit #8 Nepean, ON K2E 7Y1	tel: (613) 727-5692 fax: (613) 727-5222 e-mail: phaulena@accutestlabs.com
Agri-Food Laboratories	503 Imperial Rd Unit #1 Guelph, ON N1H 6T9	tel: (519) 837-1600 1-800-265-7175 fax: (519) 837-1242 e-mail: lab@agtest.com
Brookside Laboratories, Inc.	301 South Main St New Knoxville, Ohio 45871	tel: (419) 753-2448 fax: (419) 753-2949 e-mail: nfisher@blinc.com
Soil and Nutrient Laboratory	University of Guelph P.O. Box 3650 95 Stone Rd W Guelph, ON N1H 8J7	tel: 519-767-6226 fax: (519) 767-6240 e-mail: nschrier@lsd.uoguelph
Stratford Agri Analysis (A Daco Laboratories Ltd. company)	1131 Erie St Box 760 Stratford, ON N5A 6W1	tel: (519) 273-4411 1-800-323-9089 fax: (519) 273-4411 e-mail: saa@dacolabs.com

The soil test value is used in the OMAFRA fertilizer recommendations tables that are calibrated to relate the extractable nutrient with the amount of fertilizer required to achieve optimum crop yields.

The OMAFRA-accredited test for phosphorus uses a sodium bicarbonate solution for the extraction. This method, which is often referred to as the Olsen method, has been found to provide accurate results across the wide range of soil pH found in Ontario. Other methods that are used in neighbouring states or provinces, such as the Mehlich-3 or Bray methods, provide inconsistent results in alkaline soils, and so are not accredited for use in Ontario. They also give results on a different scale, so the output from one of these methods cannot be used with the OMAFRA fertilizer recommendation tables.

Available potassium is measured using an ammonium acetate extract. The ammonium displaces cations, such as potassium, from the negatively charged soil particles so they can be measured in solution. The same extract can be used to measure the quantity of available magnesium, calcium and sodium, if desired.

Another important parameter to be measured in a soil test is soil pH. This is a measure of the acidity or alkalinity of the soil, which in turn influences the availability of many nutrients, the ability of crops to grow and the activity of many herbicides. The pH should be measured in a soil-water paste that has just enough water to saturate the soil pores. More dilute suspensions will provide readings that are higher than the actual soil pH, particularly in coarse soils. A soil pH test is required where biosolids are to be applied.

OMAFRA-accredited tests are also available for zinc and magnesium. These are useful when comparing a good area of a field to one suspected of having a deficiency, as well as for predicting the need for supplemental nutrients but are not required for a nutrient management plan.

Nutrient management plans for biosolid application require testing for the content of regulated metals in the soil. These quantities are measured in an acid digest of the soil sample, where all the soil minerals and organic compounds are dissolved. Labs that perform this analysis must be accredited under a separate accreditation program to meet ISO/IEC 17025 standards.

What Does the Regulation Say About Required Analyses?

Samples for a nutrient management plan that includes manure application must be analyzed at an OMAFRA-accredited lab for available phosphorus and available potassium. Plans that include biosolid application must be analyzed for the same parameters, plus soil pH and regulated metals (Ontario Regulation 267/03).

USING THE RESULTS

There is more to soil fertility than a soil test report, which is a picture in time. Soil health, which includes tilth, soil structure and crop rotation will also impact nutrient cycling in the soil. Where soil samples have been collected and analyzed, these results should be used to prepare a nutrient management plan for that field. This can mean comparing the results to the OMAFRA fertilizer recommendation tables to determine fertilizer rates, or inserting the test results into a nutrient management computer program (like NMAN) or onto the Nutrient Management Worksheet, where the nutrients from all sources can be considered to calculate application rates for nutrients.

Soil sample results are also useful in a recordkeeping role for comparing the analysis data to results from previous years. Determining the increasing or decreasing soil fertility levels helps evaluate the effectiveness of the overall fertilizer program or nutrient management plan.

Using the results becomes more complex when multiple samples have been collected for a field or single management zone. Multiple sample results can come from fields that have been grid sampled. If the field size is larger than 10 ha (25 ac), it may be desirable to fertilize the entire field as one block. Table 2, next page, gives the pros and cons of a number of options for dealing with multiple sample results.

TABLE 2. Options for determining fertilizer rates from multiple sample results.

Option	Pros	Cons
Treat each area separately, applying manure or fertilizer according to the soil test for that area.	• Most precise matching of nutrients to requirements	• Complex to manage, particularly if varying multiple nutrients
Use average of soil test values for entire area to set fertilizer and manure rates.	• Single application rate, therefore, simple to manage • Nutrient application rates close to requirements for most of the field	• May result in part of the field being under-fertilized • May result in nutrient losses to the environment from parts of the field with excessive nutrients
Use highest soil test values from the available samples to set fertilizer and manure rates.	• Most environmentally conservative application rates	• May result in part of the field being under-fertilized
Use lowest soil test values from the available samples to set fertilizer and manure rates.	• Minimized risk of yield losses from under-fertilization	• May result in nutrient losses to the environment from parts of the field with excessive nutrients. • High fertilizer costs, without increasing yields

In any averaging, the results must be weighted to reflect the area included in each sample. This is done by multiplying the sample result for each parameter by the number of acres represented by that sample, and then adding the products of that multiplication for each sample in the field. This total is then divided by the total acres in the field to give a weighted average for this entire field. This process prevents a single sample from a small area skewing the results if it is widely different from the rest of the field.

Sample Calculation:

Field Section	Soil P test	Area of Section	Weighting
Front West	16	15 ac	16 x 15 = 240
Front East	32	4 ac	32 x 4 = 128
Old Barnyard	92	1 ac	92 x 1 = 92
Back West	8	25 ac	8 x 25 = 200
Back East	6	25 ac	6 x 25 = 150
TOTAL		90 ac	810

In this example, the weighted average soil P test is 9 (810 ÷ 90). If the soil test values were simply averaged, the high values for the old barnyard and the front east field would skew the number upwards and give a result of 31. On a farm that was using commercial fertilizer as the nutrient source, this represents a difference in phosphate fertilizer recommendations from 0, for the simple average, to 70 kg/ha, for the weighted average.

Where sample results are combined for a nutrient management plan, the method that is used must be noted on the plan so that anyone reviewing the plan can understand how the numbers used in the plan were derived.

See the OMAFRA website: www.omafra.gov.on.ca/crops to find the current list of accredited soil test laboratories.

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